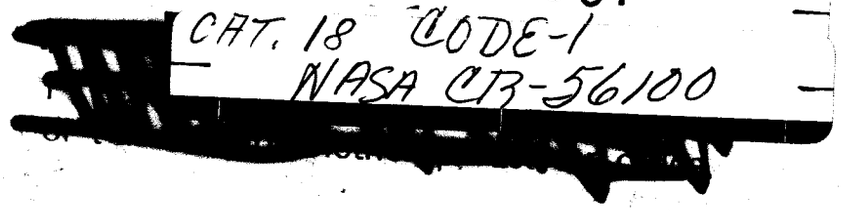
14p.



X

LMSC/A650295
NSP-64-35

ALUMINUM ALLOY 2319 WELD WIRE

INVESTIGATION

NSP-64-35

Prepared

M. V. Steen, Manager
LSVP Process Development

Approved

H. F. Plank, Director
Large Space Vehicle Programs

ALUMINUM ALLOY 2319 WELD WIRE

INVESTIGATION

FOREWORD

The cancellation of the RIFT Program and Contract NAS 8-5600 disrupted a manufacturing development program to relate weld wire imperfections to defective welds. The objective of the study was to improve the reliability of the welding process and as proven applicable to define quality acceptance criteria for 2319 aluminum alloy weld wire. The initial effort of the program had been completed prior to December 31, 1963, therefore, this report is submitted to provide the results, conclusions, and recommendations of that effort.

SUMMARY

20687 A

In mid-1963 Lockheed's Development Manufacturing engineers encountered a serious problem of defective welds in 2219 Aluminum alloy while engaged in weld development support of the RIFT program. Subsequently, the cause of the inadequate weld quality was isolated and attributed to the 2319 aluminum welding wire. The weld wire imperfections were of two major types: surface pits and foreign particulate matter adherring to the wire. Close liaison between Lockheed, Marshall Space Flight Center and the weld wire producer revealed the need for the establishment of quality acceptance criteria for 2319 weld wire.

A comprehensive investigation was initiated by Lockheed with RIFT development funds, however, the partial cancellation of RIFT terminated the effort. Prior to December 30, 1963, the investigation had resulted in a preliminary analysis of the two major types of weld wire imperfections. That analysis revealed the foreign particulate matter to be the major cause of defective welds. The weld wire producer, at the suggestion of Lockheed's engineers, has improved the spooling techniques and modified the reel - the source of the foreign matter on the wire. Author

OBJECTIVE

The objective of this report was to determine the effect of the following previously reported weld wire imperfections on radiographic weld quality:

a. visual surface defects (pits, gouges)

b. fragments from the plastic reel deposited on the wire during spooling

SCOPE

The scope of this report is confined to two types of potential weld wire problems - visible surface pits and plastic reel particles - and to one set of welding and tooling conditions. All welding was done with the direct current-straight polarity gas tungsten arc process in the flat position using 2219-T87 plate in 3/8 in. thickness.

The original investigation was to have provided comprehensive evaluation of weld wire defects with weld quality. The investigation, as reported herein, covers only the preliminary work done before December 31, 1963, the date of partial contract termination. (NAS 8-5600)

BACKGROUND

In mid-1963 the Development Manufacturing Welding Laboratory of the Nuclear Space Programs Division encountered a serious problem in producing quality weldments for the RIFT Engineering Materials and Structural Development Programs. A methodical investigation was undertaken to isolate and correct the cause of weld defects, which were revealed radiographically as porosity.

The investigation was completed and concluded " --- the major problem of weld porosity in 2219 aluminum alloy weldments is attributable to the current quality and packaging of the 2319 weld wire".[1] During the course of the investigation, samples of the weld wire were submitted to the Quality Assurance Materials and Processes Laboratory for study. A typical surface defect is shown in Figure 1. Concerning such defects the Laboratory Report concluded, in part, "The wire from lots PCN 1074 and 1140 had large surface tears which entrapped drawing lubricant --- . Wire having these defects should have been rejected by the Supplier's inspectors".[2]

In addition to the surface defects in the wire, small black foreign particles were observed throughout the spooled wire, as shown in Figure 2. The Laboratory Report regarding this contaminant stated, in part, "The wire was partially unwound and bits of the contamination were removed. There was an insufficient amount to identify these by infrared spectrum, so the contaminants were arced on the optical spectrograph. This analysis revealed the particles to be organic material with no metallic elements.

EXPERIMENTAL PROCEDURE

Several surface defects typified in Figure 1, were isolated from two spools of 1/16 inch diameter 2319 weld wire. The wire and wire feed system was thoroughly cleaned to eliminate the possibility of residual contamination entering the weld puddle. The weld parameters were established to produce a drop-through weld on .375 plate. The bead-through-plate weld was utilized to eliminate the influence of joint cleanliness variation on weld quality. Both sides of the plate were scraped immediately prior to welding. The welds were made with 300 amperes, 11.8 arc volts, Helium gas, 9 ipm travel, 63 ipm wire feed in a stake weld fixture.

The distance from the wire guide nozzle to the wire defect was determined for each defect. Then the point where the wire defect would enter the puddle was calculated and metal stamped. The approximate defect sizes are tabulated in Table I. Subsequent to welding, radiography disclosed that all weld beads were water clear.

Location of Defect Entry in Puddle	Approx. Defect Size
a.	.030 x .030
b.	.030 x .060
c.	.030 x .060
d.	.030 x .060
e.	.060 x .060
f.	.030 x .030
g.	.030 x .030
h.	.030 x .060
i.	.060 x 060
j.	.030 x .030
k.	.030 x .030
l.	.060 x .060
m.	.030 x .060

Location of Defect Entry in Puddle	Approx. Defect Size
n.	.030 x .060
o.	.030 x .030
p.	.030 x .030
q.	.030 x .030
r.	.030 x .030

Table I. Approximate size of weld wire surface defects.

The determination of the foreign particle influence on weld quality utilized the same weld procedure with carefully selected weld wire exhibiting superior surface quality. Square butt joints were utilized so as to position and hold, by center punch marks on the joint interface, small fragments of the reel material typified in Figure 2. A weld bead six feet long was made with eight reel fragments equally spaced at the joint interface. The larger particles, upon volitization, disturbed the automatic arc voltage control head sufficiently to cause a major depression in the weld. Smaller particles resulted in a black deposit on the bead, as reported previously, with good bead appearance.[1] However, the weld exhibited radiographic indications at each fragment location.

The gross surface and radiographic indications resulting from the fragments brought about a further evaluation of very small fragments. The joint edges were prepared and tack welded and then the minute fragments were wedged in the joint at eight marked locations. The plates were welded as before, resulting in good bead uniformity with some dark surface spots at the marked locations. Radiography disclosed that only two of the eight locations exhibited indications; a Class II and a Class III.

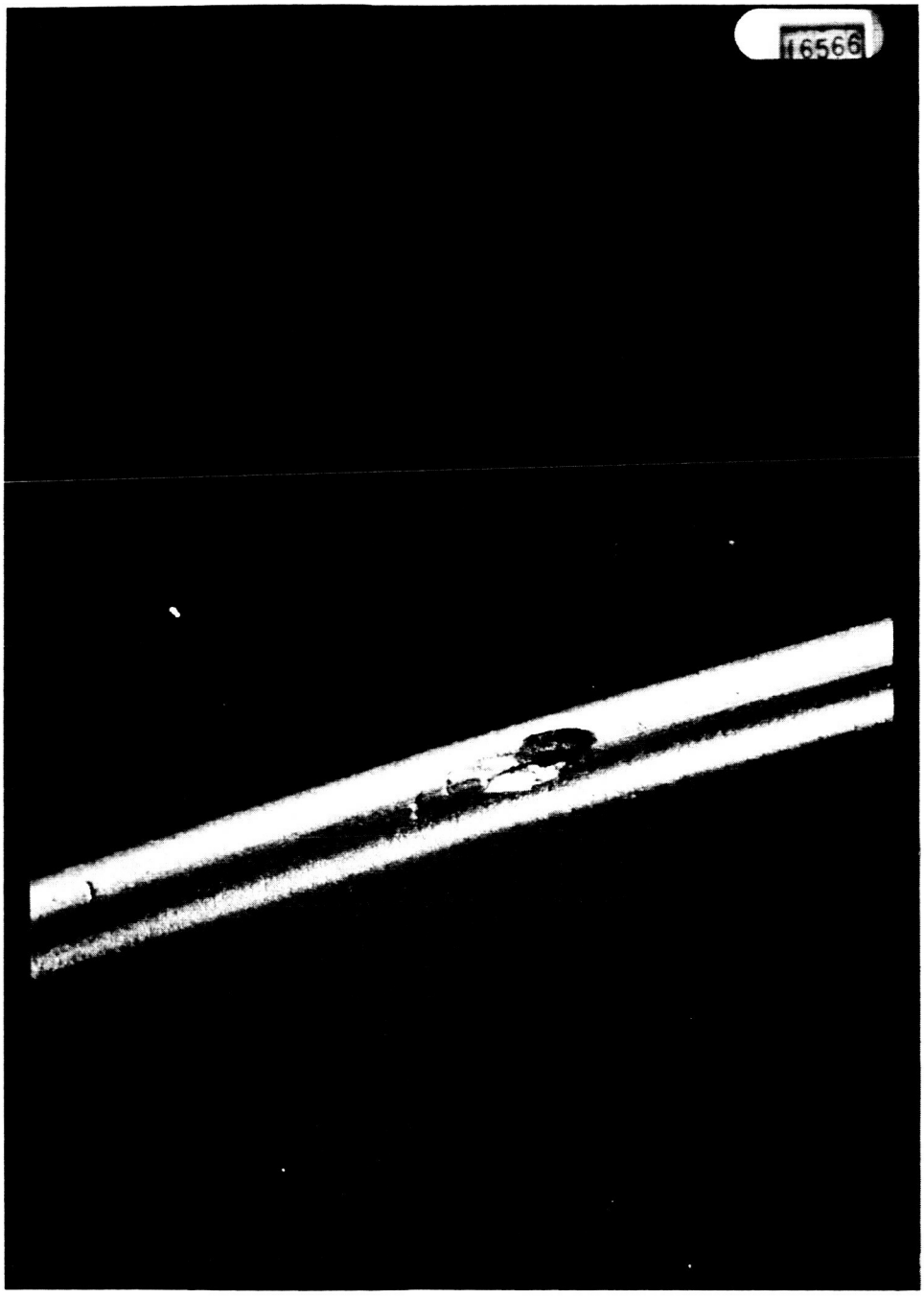


FIGURE 1 Surface defect in 2319 weld wire. 17X

FIGURE 2 Photograph, through unbroken polyethelene bag, of contaminant on 2319 weld wire. 9X

The spool holding the wire is constructed of hard plastic material. Small bits of the spool were removed and examined at high magnification. This examination revealed them to be similar in appearance to the black particles of contamination. Spectrographic and infrared analysis were made of spool chips. The results showed them to be an aromatic organic material with no metallic elements". [3]

Arrangements were made with All-State Welding Alloys Company to test sample spools of the wire utilizing the eddy current process. The results of this test program were reported to Lockheed as follows: "The first fifty foot of wire broke in the burnishing die six times. These breaks were caused by major defects in the wire. Then approximately 2600 feet of wire went through before a seventh and last break occurred. The final 400 feet was then run through inspection. At a sensitivity level of 16, only two discontinuities were graphed. On rerunning the two major segments of wire with a sensitivity level of 19, twelve discontinuities were graphed on the ten pound length and one additional discontinuity on the last 400 feet length". [4]

The maintenance of close coordination between Lockheed and MSFC representatives permitted a close liaison between MSFC and the wire supplier regarding the wire problem. As a result, MSFC personnel arranged a meeting with the wire producer in September, 1963, which was attended by representatives of MSFC, Lockheed Missiles and Space Company and Douglas Aircraft, Missile Division. At this meeting, the Lockheed representatives presented evidence demonstrating the wire quality problems - surface and sub-surface defects and foreign

particles. During a plant tour the Lockheed representatives observed the wire spooling operation and suggested improvements in both the spooling technique and the reel itself.[5] They further made a commitment to conduct an analytical investigation of the weld wire quality imperfections and their influence on weld quality.

The wire producer was very concerned about the problem, welcomed the suggestions and promised immediate improvement in the quality level. They further asked for a close technical exchange with Lockheed and others, in order to be informed of our investigative results that immediate action may be taken on their part, if warranted.

DISCUSSION

The work performed on the weld wire investigation, though very limited, definitely indicates that the major 2319 weld wire quality problem is due to the deposition of reel fragments during spooling. A single minute fragment from the plastic reel will probably not cause a weld defect, but if several minute fragments, or a larger one, enters the puddle through the wire feed system, rejectable porosity will probably result. Visual surface defects similar to that shown in Figure 1 did not result in radiographic indications, as previously postulated in Reference 1. However, this apparent contradiction is readily explained. Close examination of the wire feed tube disclosed several minute particles in the inside of the tube deposited by the weld wire. Smoothly finished wire would not carry these minute particles into the puddle, but a surface defect in the wire could act as a scraper, thus carrying the particles into the puddle. This would explain the previously reported correlation between surface defects and radiographic indications.[2]

However, the preliminary nature and limited scope of the work reported herein must be emphasized. Correlation between eddy current indications of internal or partial sub-surface defects of weld wire and weld quality should be obtained. Additional experimentation should be conducted to verify the initial results contained in this report, and to expand the accumulation of data necessary to define acceptable quality standards of 2319 weld wire.

Close liaison with the wire producer has already resulted in improved spooling techniques and a new reel has been adapted for use in packaging the wire. The general quality level of the 2319 weld wire has been improved.

BIBLIOGRAPHY

1. "Porosity in 2219 Aluminum Alloy Weldments" - LMSC, NSP Development Manufacturing Report. C. L. Cline, September, 1963.

2. "Quality of Alloy 2319 Aluminum Weld Wire" - LMSC Report No. 40845, September, 1963.

3. "Weld Wire Type 2219 - Contamination in Vacuum Sealed Bag" - LMSC Report No. 42606. September, 1963.

   "Examination of Aluminum Alloy 2319 Weld Wire" - LMSC Report No. 45279. December, 1963.

4. "Report on Radac Testing of 2319 Aluminum Welding Wire 9/12/63 at Aluminum Wire Products at Glastonbury, Connecticut", to F. I. Priszner, Lockheed, from Thomas D. Nast, President, All-State Welding Alloys Co., Inc., Dated September 13, 1963.

5. Trip Report "Visit to Alcoa's Weld Wire Facility", C. L. Cline, September 30, 1963.